"Theory and Observations of Ocean Fronts: Lagrangian Studies of Arabian Marginals"

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LONG-TERM GOALS

The ultimate goal of his research is to understand the dynamics of the mesoscale eddy field in the coastal oceans and marginal seas as an extension of the earlier work of the investigators on the open ocean eddies and fronts. The physical focus is on the interaction of different regimes; for example, the interactions from the land-side in terms of riverine input and shallow embayment dynamics versus offshore forcing in the creation of the coastal circulation features. Of particular interest is the impact of atmospheric forcing along coastal margins. Similar to the previous work, the objective is to provide an understanding of the role the physics has in producing the biological responses that influence the optical and acoustic properties of the coastal domain. The studies will explicitly consider the role of topography, sediments and benthic communities in coastal dynamics.

OBJECTIVES

The basic objective of the research is to produce large scale mapping of marginal sea environments that resolve scales down to a few kilometers and temporal scales of an hour. These measurements are then used to understand the circulation dynamics in these seas with an emphasis on the structure of flows along boundaries and in proximity to complex topography. The combination of the data sets and their analysis provides a basis for testing and improving model simulations in these marginal basins.

APPROACH

The last two years have been dedicated to procuring and deploying drifter arrays in marginal seas in the Middle East. This was carried out through the past grant and an associated DURIP sixty Global

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14. ABSTRACT

The ultimate goal of his research is to understand the dynamics of the mesoscale eddy field in the coastal oceans and marginal seas as an extension of the earlier work of the investigators on the open ocean eddies and fronts. The physical focus is on the interaction of different regimes; for example, the interactions from the land-side in terms of riverine input and shallow embayment dynamics versus offshore forcing in the creation of the coastal circulation features. Of particular interest is the impact of atmospheric forcing along coastal margins. Similar to the previous work, the objective is to provide an understanding of the role the physics has in producing the biological responses that influence the optical and acoustic properties of the coastal domain. The studies will explicitly consider the role of topography, sediments and benthic communities in coastal dynamics.

15. SUBJECT TERMS

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Positioning System in the southern Gulf. A second deployment of 15 units deployed in winter 2003 is just finishing its drift with a few units at low battery voltage left. This brings the total number of drifters in the southern Gulf to twenty. After 9/11 the remaining 40 units were deployed in the Aegean Sea in collaboration with the Greek National Center for Marine Research and the University of Athens. Four total deployments were made to provide a fairly good coverage of the annual cycle and two realizations of spring and summer. Trajectories for the total deployment, individual drifter trajectories and various additional descriptions of the array can be found on the public University of Miami sites: http://www.rsmas.miami.edu/~geoff/gpsdrifters/persian/persian.html and http://www.rsmas.miami.edu/~geoff/gpsdrifters/aegean/aegean.html.

WORK COMPLETED

The drifter deployments are nearly complete as of this writing and the initial work up of the data is well underway. The array and the first years worth of results where presented verbally and as a poster at an Aegean workshop sponsored by ONR in Rhodes in October 2002. There have also been additional presentations at EGS in France, a symposium in Greece and the IUGG meeting in Japan in July 2003 (Kourafalou et al. 2003; Olson et al., 2003a, 2003c). The data sets have been completely edited to remove bad GPS fixes (these are rare) and prepare for the final analysis.

The Aegean data set has been used to discern a general circulation pattern for the Aegean Sea which includes some new features as compared to earlier literature. This data set also allows a complete mesoscale description of the basin and the linkages between the general circulation, the mesoscale and smaller scale features in the velocity fields. The first attempts at computing Lagrangian statistics for parameters such as diffusivities show that the field is dominated by "negative viscosity." A portion of this result is induced by the sampling problems, i.e. the flow is inhomogeneous and non-stationary, but the overall character of the flow suggests a strong tendency for the flow to breakdown into small scale features as it passes through restriction around islands and straits. These then coalesce to form larger eddies as the flow evolves in the basins and along coastlines.

The Gulf data set reveals the overall circulation in the southern half of the region. The results suggest a very asymmetric circulation with a fairly swift current into the Gulf along the Iran coast and a sluggish back flow in the shallow southern side of the Gulf. The latter is dominated by a weak mesoscale field and tides. Work is underway to extract the tides over the southern Gulf using the drifter array and the earlier mooring in the Gulf (Johns et al., 2003 in press). A major factor in the "tidal" band is the impact of strong diurnal land-sea breezes. This work follows on to the work on Indian Ocean regional sea breezes with S. Chen. The later is in manuscript form and will be submitted within the next few months.

The last year has also seen the completion of several works from earlier ONR funded research. Earlier work on the meso- to submesoscale eddies on the western edge of the Gulf Stream has lead to two manuscript submissions and another IUGG talk (Olson et al., 2003b), presented at IUGG in the western boundary current session. The senior P.I.'s were co-conveners of this session. This work has also been the focus of several recent presentations at various acoustic workshops (De Ferrari and Olson 2003; De Ferrari and Olson 2002).

RESULTS

Two successful surface drifter experiments have been competed and are currently being analyzed. The analysis of the circulation of the Aegean shows rim currents driven by a combination of fresh water outflow from the Dardanelles and the along basin winds. The northern basin is dominated by a westward flow and large eddies that fill the sub basins. Currents intensify along the western boundaries to form coastal jets. The flow also enters the embayments in the northern Aegean creating closed eddies there. A new feature is the Evvoia jet along the coast of Greece. A weaker southward flow occurs along the Peloponnisos south of Athens and inflow into the Aegean is on the eastern side. The central Aegean is dominated by cyclonic gyres over deep topographic troughs. Tides are evident around the edges of these gyres. The flow in the Aegean is dominated by submesoscale mixing around islands and within straits. Following these interactions the size of features grow in scale. The details for this complex mixing and reorganization of the flow is currently being quantified.

In the southern Gulf a general depiction of the circulation is also emerging with rapid inflow on the Iranian coast and a slow return flow in the shallow southern side of the Gulf. The data set suggest tidal currents are strongly modified by wind set up with 24 period. A full depiction of these tides is being prepared for comparison with NRL and NAVO models of them.

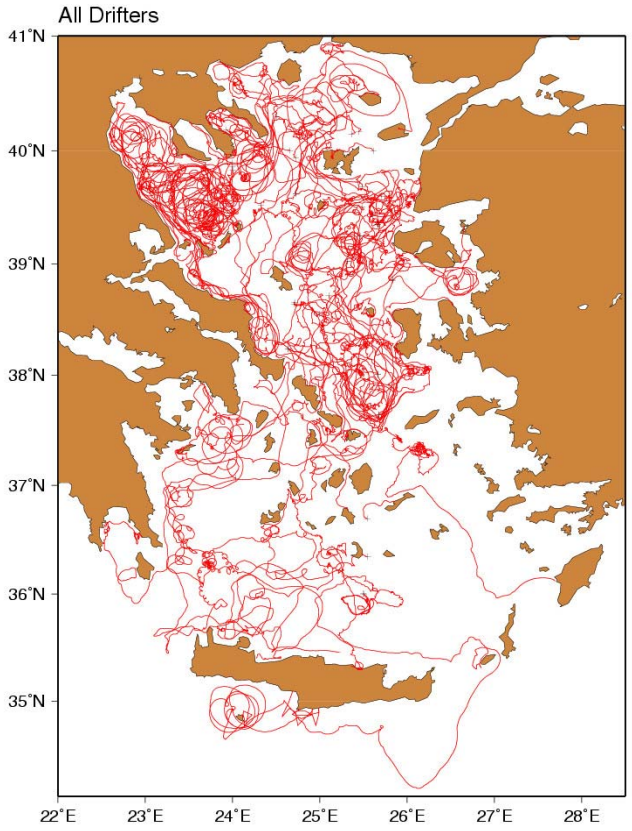

Figure 1: GNC Drifters 2002

IMPACT/APPLICATIONS

Collaborations continue with the United Arab Emirates Wildlife Service including an atlas of the drifters that is currently in preparation. This interaction is an important link to this region's science community. The collaboration with the Greeks is also continuing along with efforts to get a visitor from Greece to work on the data. Finally, work with C. Blaine and C. Horton at Stennis will continue.

TRANSITIONS

None

RELATED PROJECTS

The work on this effort and on earlier ONR funded work in the Straits of Florida and Bahamas has led to two new NSF funded programs to study the connection of the Bahamas to the greater Caribbean and to study large pelagic fish in the Gulf Stream front. The P.I. has also been participating in NAVO hydrographic cruises in the Bahamian straits. Three undergraduates took part in the May 2002 cruise.

REFERENCES

DeFerrari, H. and Olson, D.B. Sept. 2003. Mesoscale effects on acoustic propagation in the Straits of Florida. Shallow Water Workshop ARL, Seattle, WA.

DeFerrari, H. and Olson, D.B. October 8-10 2002. Mesoscale eddies as a predictor of shallow water sonar performance. UASP Workshop Special Session on Capturing Uncertainty Newport, RI

Esenkov, O. and Olson, D. B. A Numerical Study of the Somali Coastal Undercurrent. *Dep Sea. Res II,* 2002, pp. 1253-1277.

Johns, W.E., Yao, F. Olson, D.B., Josey, S.A., Grist, J.P. and Smeed, D.A. 2003. Observations of seasonal exchange through the Straits of Hormuz and the inferred heat and freshwater budgets of the Persian Gulf. *J. Geophys. Res*. (in press).

Kourafalou, V.H., Olson, D.B., Johns, W., Kontoyiannis, H. and Zervakis, V. 2003. Structure of flows in the Northern Aegean Sea from a pilot drifter array. (Abstract). EGS-AGU-EUG 2003 General Assembly, Nice, France. Geophysical Research Abstracts, vol. 5, 07767. (Online) Available http://www.cosis.net/abstracts/EAE03/07767/EAE03-J-07767.pdf

Olson, D.B., Kourafalou, V.H., Johns, W., Kontoyiannis H. and Zervakis, V. 2003a. The Aegean Sea Pilot Drifter Program. 7th Panhellenic Symposium of Oceanography and Fisheries, Crete, Greece.

Olson, D.B., DeFerrari, H. A., Johns, W., Shay, L., Lee, T. July 2003b. Mesoscale Modulation of Cross Shelf Exchange in The Florida Straits. (Abstract). IUGG2003, Sapporo, Japan.

Olson, D.B., Kourafalou, V., Johns, W. July 2003c. Lagrangian Observations of the Surface Circulation of the Northern Aegean Sea. (Abstract). IUGG2003, Sapporo, Japan.

PUBLICATIONS

Niiler, P. P., Maximenko, N.A., Panteleev, G.G., Yamagata, T. and Olson, D.B. 2003. Near-surface dynamical structure of the Kuroshio Extension, *J. Geophys. Res.,*108 (C6), 3193, doi:10.1029/2002JC001461.

Olson, D.B. 2002 Biophysical Dynamics of Ocean Fronts. *The Sea.,* **12**, 2002, 187-218.

O'Connor, B.M., Fine, R.A., Maillet, K.A. and Olson, D.B. 2002. Formation Rates of Subtropical Underwater in the Pacific Ocean. *Deep-Sea Res*., 49,1571-1590.

HONORS/AWARDS/PRIZES

Olson, D.B. (lead PI) has been named as an Associate editor of the Journal of Marine Science.